

Metallicity dependence of UV dissociation of CO molecules in protostellar outflows

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Throughout the 13.8 billion years of cosmic history, the star formation environment has been continuously changing. In particular, since the metallicity has increased with the evolution of the universe, it is important to investigate the star formation process in low metallicity environments in order to understand the star formation process in the past. Investigating the star formation process will also help us to understand the initial conditions for planet formation.

The Small Magellanic Cloud, a nearby dwarf galaxy, has a low metallicity of 0.2 solar metallicity and is an environment that simulates an old galactic system. Recently, CO molecular emission line observations of star-forming regions in the Small Magellanic Cloud have reported weak protostellar outflows. This result may suggest that the star formation process at low metallicity is different from that in the Galactic environment. However, we cannot rule out the possibility that the outflows that can be measured by CO emission lines are simply not visible in low metallicity environments with few dust particles because the UV light penetrates well and CO molecules are easily photodissociated.

The purpose of this study is to clarify whether the observed "weak outflow in the Small Magellanic Cloud" can be explained by photodissociation of CO molecules by protostellar UV. Therefore, a model is constructed to calculate the attenuation of protostellar ultraviolet radiation in the outflow due to dust absorption and the UV dissociation and production of CO molecules to obtain the CO abundance. The dependence of the CO abundance on these physical parameters was investigated by performing the calculations for various values of protostellar luminosity and deuterium abundance. The dust abundances were assumed to be proportional to the metallicity. From the obtained CO abundance distribution, the outflow mass observable in CO was determined and compared with the observed results.

The results showed that the CO abundance decreased at low metallicity, and the outflow mass observable in CO also decreased, indicating the importance of optical thickness for dust attenuation in the outflow from the CO abundance distribution. Since the optical thickness also depends on the outflow radius, we performed calculations with different outflow radii and were able to reproduce the observed results. This suggests that the universality of the star formation process at metallicity of 1-0.2 solar metallicity was not ruled out. On the other hand, photochemical processes were found to be strongly dependent on the metallicity, suggesting that more detailed modeling from the viewpoint of matter formation and evolution is needed in the future.